1.0 Introduction

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting their designated uses even though pollutant sources have implemented technology-based controls. A TMDL establishes the allowable load of a pollutant or other quantifiable parameter based on the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollutant loads from both point and nonpoint sources and restore and maintain the quality of the state's water resources (USEPA, 1991).

Due to their high nutrient concentrations and/or low dissolved oxygen levels, the Delaware Department of Natural Resources and Environmental Control (DNREC) identified and included in the state's 1996, 1998, and 2002 Section 303(d) lists of impaired waters several portions of the Appoquinimink River. This study will fulfill the requirements for nutrient and dissolved oxygen (DO) TMDLs for all waters in the Appoquinimink River basin included in the State's 1996 and 1998 303(d) lists.

In 1996, the USEPA was sued under Section 303(d) of the CWA concerning the 303(d) list and TMDLs for the State of Delaware. Ths lawsuit maintained that Delaware had failed to fulfill the requirements of Section 303(d) and the EPA had failed to assume responsibilities not adequately performed by the State. A settlement in the lawsuit was reached and DNREC and EPA signed a Memorandum of Understanding (MOU) on July 25, 1997. Under the settlement, EPA agreed to complete TMDLs for all 1996 listed waters according to a 10-year schedule if the state failed to do so. Under the requirements of the suit settlement DNREC began this TMDL in order to compete the TMDL by December 30, 2002 but, because of various issues, requested EPA to complete the work. Because EPA is developing the TMDL the establishment date, in accordance with the suit settlement agreement, is December 15, 2003.

1.1 Background Information

The Appoquinimink River drains approximately 47 square miles in New Castle County, Delaware (Figure 1-1). Major tributaries in the basin include Drawyer Creek and Deep Creek. There are several small, shallow, man-made lakes and ponds in the watershed (Wiggins Mill Pond, Noxontown Lake (pond), Silver Lake, and Shallcross Lake). All tributaries mentioned are included within the listing for the mainstem of the Appoquinimink River on Delaware's 303(d) list of impaired waters.

The Appoquinimink River watershed is primarily agricultural with three residential/urban centers (Middletown, Odessa, and Townsend). The area is experiencing considerable residential growth. The topography is generally characterized by flat to gently sloping land which is typical

of the coastal plain.

The Appoquinimink River is designated as a warm-water fishery and is subject to all water

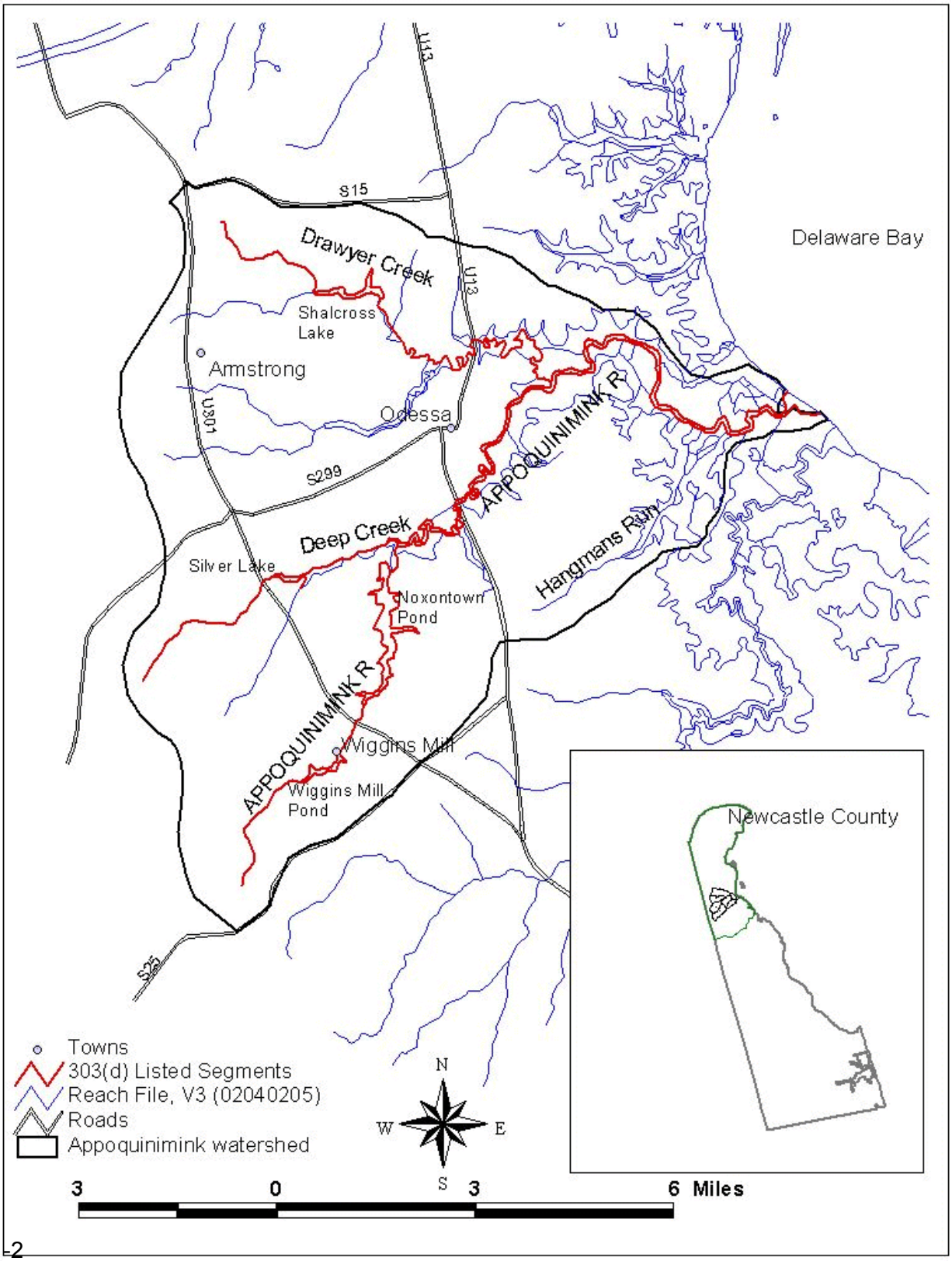

Figure 1-1. Appoquinimink River basin; stream segments on 1998 303(d) list are bold (red).

quality criteria specific to this designated use and those defined for general statewide water uses including aquatic life, water supply, and recreation. Several stream segments of the Appoquinimink River basin have been cited on the State's 303(d) list of impaired waters for failing to attain their applicable criteria.

The Appoquinimink River is tidal from the confluence with Delaware Bay to the dam at Noxontown Lake on the main stem, the dam at Silver Lake on Deep Creek, and the confluence with Drawyer Creek. Salinity intrusion from Delaware Bay typically reaches upstream past the Drawyer Creek confluence at river kilometer (Rkm) 8.5. The only non storm water point source in the watershed is the Middletown-Odessa-Townsend wastewater treatment plant (MOT WWTP) located at Rkm 10. Although the MOT WWTP primarily uses spray irrigation to dispose of its effluent, it is also permitted to discharge to the surface waters of Appoquinimink River.

1.2 Impairment Listing

TMDL development for this study was limited to nutrient and DO impairments in the Appoquinimink River basin. Eight stream segments in the Appoquinimink River basin were included in Delaware's 1996, 1998, and 2002 Section 303(d) lists due to nutrient and low DO impairments (see Table 1-1 and Figure 1-1). These include 2 segments of the Appoquinimink River mainstem as well as 3 tributary stream segments and 3 small lakes or ponds. Probable sources of nutrients have been identified as the municipal point source and nonpoint source runoff.

Table 1-1. Nutrient and DO impaired stream segments of the Appoquinimink River basin.

Segment Name	Segment ID	Size Affected	Pollutant and/or Stressor	Probable Sources	Year Listed
Appoquinimink River (Lower)	DE010-001-01	7.1 miles	Nutrients, DO	PS, NPS	1996
Appoquinimink River (Upper)	DE010-001-02	6.1 miles	Nutrients, DO	PS, NPS	1996
Drawyer Creek	DE010-001-03	8.2 miles	Nutrients, DO	NPS	1996
Wiggins Mill Pond to confluence with Noxontown Pond	DE010-002-01	3.4 miles	DO	NPS	1996
			Nutrients	NPS	2002
Deep Creek to confluence with Silver Lake	DE010-002-02	2.4 miles	DO	NPS	1996
			Nutrients	NPS	2002
Noxontown Pond	DE010-L01	158.6 acres	Nutrients	NPS	1998
Silver Lake	DE010-L02	38.7 acres	Nutrients	NPS	1996
Shallcross Lake	DE010-L03	43.1 acres	Nutrients	NPS	1996

1.3 Water Quality Standards

Section 10 of the State of Delaware Surface Water Quality Standards, as amended August 11, 1999, specifies the following designated uses for the waters of the Appoquinimink River basin: primary contact recreation; secondary contact recreation; fish, aquatic life, and wildlife; industrial water supply; and agricultural water supply (freshwater segments only).

The following sections of the State of Delaware Surface Water Quality Standards, as amended August 11, 1999, provide specific narrative and/or numeric criteria concerning the waters of the Appoquinimink River basin:

(1) Section 3: General guidelines regarding Department's Antidegradation policies
(2) Section 7: Narrative and numeric criteria for controlling nutrient enrichment in waters of the State
(3) Section 9: Specific narrative and numeric criteria for toxic substances
(4) Section 11: General water criteria for surface waters of the State.

Although there are no numeric criteria for nutrients in the waters of the Appoquinimink River basin, Section 7 of Delaware's Surface Water Quality Standards contains the following narrative criteria:

> *Nutrient overenrichment is recognized as a significant problem in some surface waters of the State. It shall be the policy of this Department to minimize nutrient input to surface waters from point and human induced non-point sources. The types of, and need for, nutrient controls shall be established on a site-specific basis. For lakes and ponds, controls shall be designed to eliminate overenrichment. For tidal portions of stream basins of Indian River, Rehoboth Bay, and Little Assawoman Bay, controls needed to attain submerged aquatic vegetation growth season (approximately March 1 to October 31) average levels for dissolved inorganic nitrogen of 0.14 mg/L as N, for dissolved inorganic phosphorus of 0.01 mg/L as P, and for total suspended solids of 20 mg/L shall be instituted. The specific measures to be employed by existing NPDES facilities to meet the aforementioned criteria shall be as specified in Section 11.5(d) of these standards. Nutrient controls may include, but shall not be limited to, discharge limitations or institution of best management practices.*

In the absence of numeric nutrient criteria, DNREC has decided upon threshold levels of 3.0 mg/L for total nitrogen (TN), and 0.1 mg/L for total phosphorus (TP) in determining whether a stream should be placed on the State's 303(d) list of impaired waters.

Section 11 of the Standards contains numeric criteria for DO and the following water quality criteria are applicable to fresh and marine waters of the Appoquinimink River basin:

General Criteria for Dissolved Oxygen in Fresh Waters

(a) Average for the June-September period shall not be less than 5.5 mg/L.
(b) Minimum shall not be less than 4.0 mg/L.

(c) In cases where natural conditions prevent attainment of these criteria, allowable reduction in dissolved oxygen as a result of human activities shall be determined through application of the requirements in Sections 3 and 5 of these Standards.

(d) The Department may mandate additional limitations on a site-specific basis in order to provide incremental protection for early stages of fish.

General Criteria for Dissolved Oxygen in Marine Waters

(a) Average for the June-September period shall not be less than 5.0 mg/L.

(b) Minimum shall not be less than 4.0 mg/L.

(c) In cases where natural conditions prevent attainment of these criteria, allowable reduction in dissolved oxygen as a result of human activities shall be determined through application of the requirements in Sections 3 and 5 of these Standards.

(d) The Department may mandate additional limitations on a site-specific basis in order to provide incremental protection for early stages of fish.

According to Section 2 of the Standards, fresh waters are defined as waters of the state which contain natural levels of salinity of 5 parts per thousand (ppt) or less, and marine waters contain natural levels of salinity in excess of 5 ppt. The water quality standards for DO and nutrients are summarized in Table 1-2.

Table 1-2. Numeric water quality standards for Delaware.

Parameter	Comments	Criteria		Period
Dissolved Oxygen		Average (mg/L)	Minimum (mg/L)	
	Fresh waters (i.e., salinity less than 5.0 ppt)	5.5	4.0	Jun 1 to Sep 30
	Marine waters (i.e., salinity equal to or greater than 5.0 ppt)	5.0	4.0	Jun 1 to Sep 30
	Both fresh and marine waters	Not specified	4.0	Oct 1 to May 31
Ammonia Nitrogen	No numeric criteria; narrative statement for prevention of toxicity. EPA water quality criteria for ammonia nitrogen toxicity used for TMDL.	pH dependent		year round
Nitrate Nitrogen	Maximum contaminant level for public drinking water systems.	10 mg/L as N		year round
Total Nitrogen	Target for Appoquinimink River basin proposed by DNREC.	3.0 mg/L as N		year round
Total Phosphorus	Target for Appoquinimink River basin proposed by DNREC.	0.2 mg/L as P		year round